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R. Tallis

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

ATTORNEY DOCKET NO. 30005981-3

Applicant: David Neil SLATTER

Title: MEASUREMENT APPARATUS

Appl. No.: Unassigned

Filing Date: 01/30/2002

Examiner: Unassigned

Art Unit: Unassigned

CLAIM FOR CONVENTION PRIORITY

Commissioner for Patents
Washington, D.C. 20231

Sir:

The benefit of the filing date of the following prior foreign application filed in the following foreign country is hereby requested, and the right of priority provided in 35 U.S.C. § 119 is hereby claimed.

In support of this claim, filed herewith is a certified copy of said original foreign application:

Great Britain Application No. 0102413.2 filed January 31, 2001.

Respectfully submitted,

January 30, 2002
Date

William T. Ellis
Registration No. 26,874

HEWLETT-PACKARD COMPANY
Intellectual Property Administration
P.O. Box 272400
Fort Collins, Colorado 80527-2400

The Patent Office
Concept House
Cardiff Road
Newport
South Wales
NP10 8QQ

I, the undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) of the Deregulation & Contracting Out Act 1994, to sign and issue certificates on behalf of the Comptroller-General, hereby certify that annexed hereto is a true copy of the documents as originally filed in connection with the patent application identified therein.

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Signed

Dated 16 March 2001

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31JAN01 E602185-1 D01463
P01/7700 0.00-0102413.2

Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

The Patent Office

Cardiff Road
Newport
South Wales
NP10 8QQ

1. Your reference — 30005981 GB

2. Patent application number
(The Patent Office will fill in this part) — **0102413.2** — 31 JAN 2001

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

Hewlett-Packard Company
3000 Hanover Street
Palo Alto
CA 94304, USA

Patents ADP number *(if you know it)*

4 965880004

If the applicant is a corporate body, give the country/state of its incorporation — Delaware, USA

4. Title of the invention — Measurement Apparatus

5. Name of your agent *(If you have one)*

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

Richard A. Lawrence
Hewlett-Packard Ltd, IP Section
Filton Road
Stoke Gifford
Bristol BS34 8QZ

Patents ADP number *(if you know it)*

7448038001

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*

a) any applicant named in part 3 is not an inventor, or
b) there is an inventor who is not named as an applicant, or
c) any named applicant is a corporate body.
See note (d))

Yes

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	
Description	5
Claim(s)	2
Abstract	1
Drawing(s)	2 KL SW

10. If you are also filing any of the following, state how many against each item.

Priority documents	-
Translations of priority documents	-
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	1
Request for preliminary examination and search *(Patents Form 9/77)*	1
Request for substantive examination *(Patents Form 10/77)*	-
Any other documents *(please specify)*	Fee Sheet

11. I/We request the grant of a patent on the basis of this application.

Signature Richard A. Lawrence Date 31/01/2001 31/01/01

12. Name and daytime telephone number of person to contact in the United Kingdom

Meg Joyce Tel: 0117-312-9068

Warning

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Notes

a) *If you need help to fill in this form or you have any questions, please contact the Patent Office on 08459 500505.*

b) *Write your answers in capital letters using black ink or you may type them.*

c) *If there is not enough space for all the relevant details on any part of this form, please continue on a separate sheet of paper and write "see continuation sheet" in the relevant part(s). Any continuation sheet should be attached to this form.*

d) *If you have answered 'Yes' Patents Form 7/77 will need to be filed.*

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Measurement Apparatus

This invention relates to measurement apparatus and, in particular, to apparatus for measuring length, surface area, volume and the like of three dimensional objects.

In many different applications it is desirable to be able to accurately measure the length, surface area or volume, for example, of an object or enclosure. In particular, for example, it is often desirable to be able to estimate the quantity of paint or wallpaper one might require to decorate a room, or the number of tiles which may be required to cover a roof. However, it is often impractical, difficult or simply impossible to measure the required dimension by hand using a tape measure or the like.

US Patent No. 4,730,190 describes a hand-held measuring device which operates effectively as a remote tape measure. Thus, the user measures the three dimensions of, for example, a room and the device multiplies the three dimensions to give the volume of the room.

However, this type of device is time-consuming to use and prone to error. Further, it is really only suitable for giving accurate volume measurements of substantially uniform right-angled areas. It would not give an accurate measurement for an area having curved or irregular sides, for example, and straight line approximations are not accurate enough for many applications. Further, the area to be measured must be accessible to the user in order for the relevant lengths to be measured. Thus, for example, it would be difficult for a user to measure the volume or surface area of a roof without having to climb up on the roof to take the relevant measurements.

We have now devised an arrangement which overcomes the problems outlined above. In accordance with the present invention, there is provided a measurement apparatus comprising imaging means for creating a three-dimensional map and displaying an image of an object or area to be measured, means for mapping a virtual shape onto said image and substantially matching said shape to the object or area to be measured, and means for determining at least one of a length,

surface area or volume of said object or area.

The present invention also extends to a method of measuring an object or area, the method comprising the steps of creating a three-dimensional map and displaying an image of an object or area to be measured, mapping a virtual shape onto said image, substantially matching said virtual shape to said object or area being measured, and determining at least one of a length, surface area or volume of said object or area.

The apparatus preferably includes means for marking or otherwise selecting the object or area to be measured within an image, by defining an outline of the shape of said object or area. The apparatus then preferably creates a virtual shape which substantially matches the outline. The apparatus beneficially includes means for permitting the user to alter one or more of the size, angle or pitch of the virtual shape.

Thus, the present invention employs an imaging technique which can recover depth as well as azimuth and elevation. The apparatus of the present invention is particularly (but not exclusively) useful for quickly and accurately estimating quantities of, for example, paint, wallpaper, tiles or carpet required for a particular area. In fact, the apparatus may include means for providing an estimate of the amount of such materials which are required. It may also include means for taking into account standard material widths, lengths, volumes, etc, when estimating the quantities of a material required to be obtained.

An exemplary embodiment of the present invention will now be described with reference to the accompanying drawings, in which:

FIGURE 1 is a schematic diagram to illustrate the "correspondence" and triangulation techniques used in some prior art imaging devices to construct a three-dimensional map of an object, area or environment;

FIGURE 2 is a schematic representation of an exemplary embodiment of the present invention in which a user has marked or drawn around an object or area of interest;

FIGURE 3 is the apparatus of Figure 2 in which a virtual shape has been created and demonstrating that the user can alter the shape with a plurality of degrees of freedom to substantially match it to the object or area of interest; and

FIGURE 4 is the apparatus of Figure 3 in which the surface area of the object or area of interest is calculated and displayed.

There are various imaging devices in accordance with the prior art which can construct a three dimensional map of an object, area or environment of interest. Generally, in these devices, two or more imaging devices, such as cameras, are separated in space and arranged to capture a respective image of the object, area or environment of interest.

Referring now to Figure 1 of the drawings, two imaging devices 10, 12 are arranged in spaced apart relation relative to an object 14 of interest. The degree of separation d of the imaging devices 10, 12 is known or can be measured.

Correspondence between the image points for each point on the object 14 as captured by the imaging devices 10, 12 is established by a pattern matching algorithm. For example, Stereo (two image) adaptive least square matching as described in Chapter 8 of Close Range Photogrammetry and Machine Vision edited by K.B. Atkinson (Whittles Publishing 1996). The position of an image point in the image plane of a camera along with knowledge of its focal length directly gives the azimuth and elevation angle of the object point relative to that camera.

The depth of the point on object 14 can now be established by "triangulation" in which an imaginary triangle is drawn between the point on object 14 and the corresponding points on the images (as shown in Figure 1). In the simplest case when the elevation angle is zero, the imaginary triangle has baseline length d and the two angles at the base of the triangle are the azimuth angles of the object point as seen from each camera. The distance of the object from the baseline can now be calculated using standard trigonometrical

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formulae. See Three Dimensional Computer Vision by Olivier Faugeras (MIT Press 1993) for a full mathematical treatment.

The result is an image of the object 14 made up of a plurality of pixels, each of the pixels containing (or having associated therewith) a depth value (i.e. information relating to the depth) for all points on the object 14. In other words, an image of the object 14 in which the three-dimensional position of each pixel is known.

Referring now to Figure 2 of the drawings, in the apparatus according to an exemplary embodiment of the present invention, such a three dimensionally mapped image of an environment of interest is created and displayed on a screen 16. The user can mark the area 22 of the image which is required to be measured, using, for example, any known video display pen marking methods on a touch-sensitive screen 16, by drawing roughly around the apparent edges of the area 22.

The apparatus further comprises a menu 18 (also displayed on the screen 16) giving a user the option to select one of a number of predefined measurements, such as length, surface area, volume, etc. The user selects a desired measurement for the marked area 22.

The apparatus then creates a virtual shape 20 to match the selected area 22 and overlays it on the image. The user can alter the size, pitch angle, etc. of the virtual shape 20 as required to match it as closely as possible to the area of interest (see Figure 3). It is envisaged to provide up to six degrees of freedom to the user for alteration of the virtual shape 20 to match it to the area 22 of interest.

Once the virtual shape 20 is as closely matched as possible, the user selects the calculate option. Because the è, ö and r values of all coordinates of the area 22 are known, the same values of all coordinates of the virtual shape 20 are also known. Further, the focal length of the imaging devices 10, 12 are known (or can be determined), so measurements such as surface area, volume, etc. of the area 22 of interest can be accurately calculated (see Figure 4).

Thus, estimates of length, surface area, volume, etc. can be quickly and efficiently obtained.

It is envisaged that, in an alternative embodiment of the invention, the apparatus may be arranged to automatically match the virtual three-dimensional shape onto the area of interest. Further, it is envisaged that the apparatus may also provide a plurality of predefined virtual shapes for selection by the user, which can then be dragged into the image space.

An algorithm for fitting standard material widths to irregular areas could also be employed.

An embodiment of the present invention has been described above by way of example only, and it will be apparent to a person skilled in the art that modifications and variations can be made without departing from the scope of the invention as defined in the appended claims.

Claims

1) Measurement apparatus comprising imaging means for creating a three-dimensional map and displaying an image of an object or area to be measured, means for mapping a virtual shape onto said image and substantially matching said shape to said object or area to be measured, and means for determining at least one of a length, surface area or volume of said object or area.

2) Measurement apparatus according to claim 1, comprising means for marking or otherwise selecting the object or area to be measured within an image, including means for defining an outline of the shape of said object or area.

3) Measurement apparatus according to claim 2, comprising means for creating a virtual shape which substantially matches said outline and for mapping said virtual shape onto said image of said object or area to be measured.

4) Measurement apparatus according to any one of the preceding claims, including means for altering one or more of the size, angle or pitch of said virtual shape so as to substantially match it to said image of said object or area to be measured.

5) Measurement apparatus according to claim 4, wherein said means for altering said size, angle and/or pitch of said virtual shape is user-controllable.

6) Measurement apparatus according to any one of the preceding claims, including means for calculating and displaying an estimate of materials required to cover said object or area, said calculating means preferably being arranged to take into account standard material values and/or quantities when calculating said estimate.

7) Measurement apparatus substantially as herein described with reference to the accompanying drawings.

8) A method of measuring an object or area, the method comprising the steps of creating a three-dimensional map and displaying an image of an object or area to be measured, mapping a virtual shape onto said image, substantially matching said virtual shape to said object or area being measured, and determining at least one of a length, surface area or volume of said object or area.

9) A method according to claim 8, further comprising the step of marking or otherwise selecting said object or area by defining an outline of the shape of said object or area.

10) A method according to claim 9, further comprising the step of creating a virtual shape which substantially matches said outline and mapping said virtual shape onto said image of said object or area being measured.

11) A method according to any one of claims 8 to 10, further comprising the step of altering one or more of the size, angle or pitch of said virtual shape so as to substantially match it to said image of said object or area being measured.

12) A method of measuring an object or area, the method being substantially as herein described with reference to the accompanying drawings.

Abstract

Measurement apparatus for measuring at least one of a length, surface area or volume of an object (or portion thereof) or area (22) (or portion thereof). The apparatus includes means for creating a three-dimensional map of an object or area to be measured and a touch-sensitive screen (16) for displaying the mapped image of the object or area. The user can select the area (22) of interest by drawing around it on the screen to create an outline of its shape and the apparatus then creates a virtual shape (20) which matches the outline and maps it onto the image. The user can alter the size, angle, pitch, etc. of the virtual shape (20) until it matches the area (22) exactly and the apparatus then determines the length, surface area and/or volume of the area (22), as required.

Figure 3

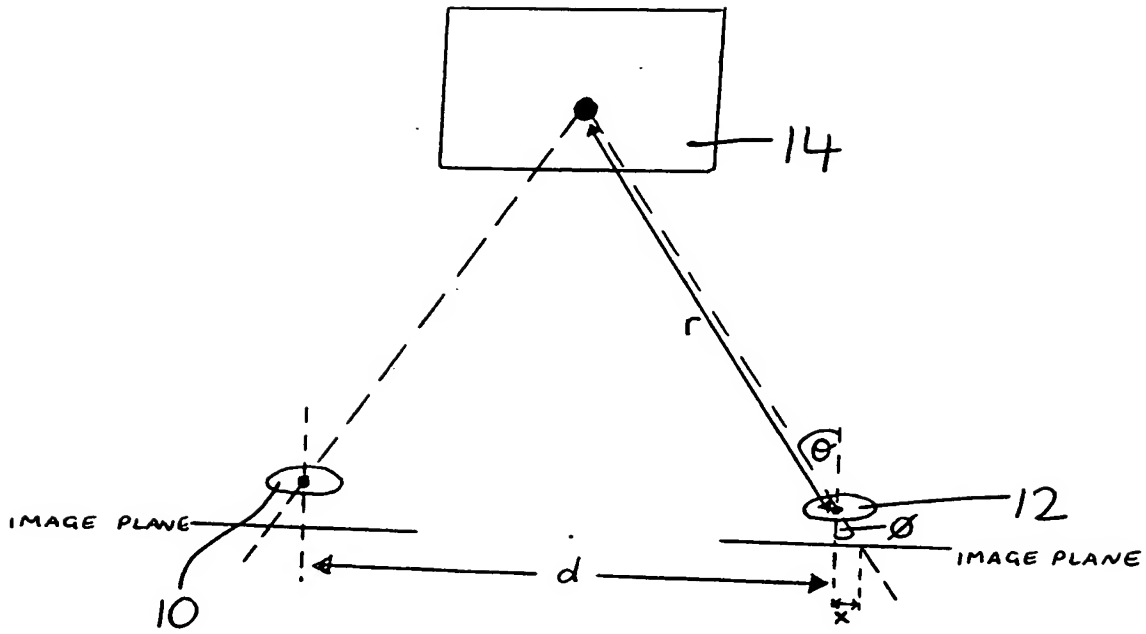

FIG. 1

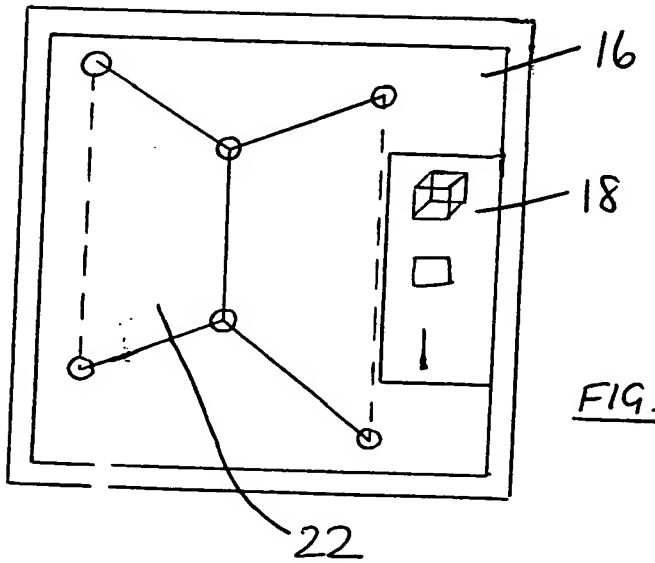

FIG. 2

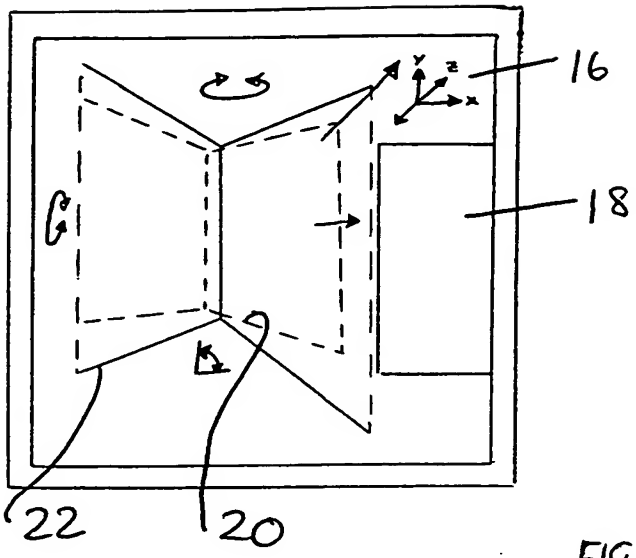

FIG. 3

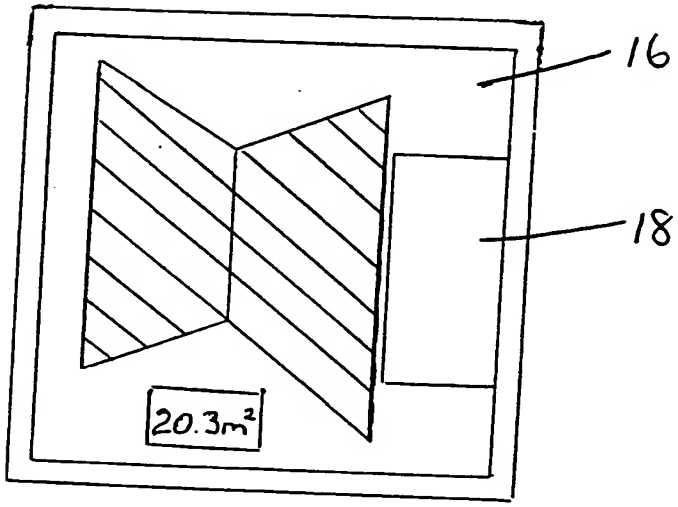

FIG. 4